ORIGINAL RESEARCH

Impact of late sowing on morphological and yield traits in 40s bread wheat

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ABSTRACT

The unpredictability and large fluctuation of the climatic conditions in rainfed regions influences spring wheat yield and grain quality. These variations offer the opportunity for the production of better quality wheat. The effect of late sowing on wheat morphology and grain yield was studied in different 40s bread wheat at the research farm of PBG, The University of Agriculture Peshawar, Pakistan during 2013-14. Forty wheat genotypes were tested under normal and late sowing in 5 × 8 alpha lattice design with three replicates. Combined analysis of variance exhibited significant genotype by environment interactions for days to heading, flag leaf area, days to maturity, plant height, spikes m^{-2}, grains $spike^{-1}$,1000-grain weight, biomass yield, grain yield and harvest index. Days to emergence, headings, maturity ranged from 9 to 12, 111 to 121 and 155 to 164 days under normal while under late planting it ranged from 25 to 29, 95 to107 and 137 to 143 days. Mean data under normal planting ranged between 77 to 125cm; 25 to 41cm^2; 99 to 199; 10 to 13 cm 32 to 49; 52 to 88g; 8533 to 13667 kg, 1869 to 4681 kg; 21 to 35% whereas under late planting its range was 63 to 91 cm, 18 to 37 cm^2, 57 to 137, 8 to 12 cm, 22 to 52, 36 to 75g, 2400 to 7933 kg, 540 to 2739 kg and 20 to 42% for plant height, flag leaf area, spikes m^{-2}, spike length, grains $spike^{-1}$, 1000-grain weight, biomass, grain yield and harvest index, respectively. Wheat genotypes planted at late condition took maximum days to emergence, while less number of days were reacquired for wheat genotypes planted at normal sowing date to get mature. Late planting negatively affected all yield contributing traits like; spikes m^{-2} (29%), grains $spike^{-1}$ (18%) 1000-grain weight (29%), biomass (55%) and grain yield (50%). On the basis of the current exploration, it is obtained that genotype SRN 19111 was identified superior for 1000-grain weight, biomass yield and grain yield under normal planting, while genotype PR-107 exhibited higher grain yield under late planting. Therefore, these genotypes are recommended for further extensive testing.

KEYWORDS: Alpha lattice design, genotypes, sowing time, wheat yield and yield components

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1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the major cereal crops in the world known for its high nutrient values (Adnan et al., 2017; Dutta et al., 2019). Cereal crops; wheat, rice and maize account for roughly half of the world's human caloric intake (Rosenthal and Ort, 2012). Wheat is regarded as a staple food crop in most of the countries including Pakistan. World wheat production during 2009-10 decreased to 0.32% as compared to the previous cropping season (2008-09), whereas 5.4% decrease in production was estimated for the 2010-2011 season. This decrease in wheat production might be due to several reasons such as improper agronomic practices, poor management and unfavorable weather conditions such as high temperature, drought and salinity (Ali et al., 2019). The assessment and characterization of plant germplasm are vital for usage of genetic resources of any type (Ali et al., 2019; Vigna et al., 2011). Wheat genotype developed through modern technologies is having good yield and achieved to having good harvest index. However, there is still a gap to develop and select new wheat genotype which can resist the harsh environmental condition and giving high yield (Riazuddin et al., 2010). It has been observed that about 80 % of the wheat crop in Pakistan is late sown, while only 20 % of the wheat crop in sown at normal planting time. Planting of the wheat crop at normal sowing time could add about two million ton of wheat to the national production of wheat. The causes of delay in sowing of wheat may be due to the presence of previous crops in the field and the absence of quality and timely agriculture input because of these reasons at grain filling stage the wheat crop is induced to terminal high temperature due to which the yield of the wheat crop is reduced much. Production of tillers, kernel size, 1000-grain kernel weight, spike length, biomass yield, grain yield and harvest index are decreased that may vary from genotype to genotype. High temperature may also negatively affect other biochemical and physiological functions in wheat crop (Hamam and Khaled, 2009; Kattenberg et al., 1995; Reynolds et al., 2001). Delay in sowing of wheat after 10th November may cause 42 kg ha^{-1}loss in yield (Khan, 2003). The probability of invasion of pest disease attacks, drought and high-temperature shocks are more for wheat genotype sown late. Therefore, the normal planting of wheat crop shows good results for obtaining good yield. Molecular and conventional approaches can play a vital role in the development of wheat genotypes that are high-yielding and having adoption to various environmental risks.

Production considerations like vegetative growth, grain yield and quality is more affected by planting time. The research work carried out on planting date may be helpful for wheat growers to obtain optimum yield from their farming. Late sowing increases the risk of yield loss (Ehdaie et al., 2001). Morphological and yield traits are directly related with the sowing time. Mid-November sowing produces the highest number of tillers m^{-2}, spike m^{-2}, 1000 grain weight and grain yield (Nasser 2009). Early or late sowing increases the risk of yield losses (Ehdate et al., 2001). Similarly biomass accumulation, grain yield, number of spikes

m^{-1} and 1000 grain weight of wheat were increased with early (early November) sowing over late (December) sowing as reported by Aftab et al. (2004). The present study was carried out to find out the impacts of late sowing in morphological and yield traits in newly developed wheat genotypes.

2. MATERIALS AND METHODS

2.1 Experimental location and weather detail

The field experiment was carried out at the Research Farm of PBG, The University of Agriculture Peshawar, Khyber Pakhtunkhwa, Pakistan during 2013-14. The farm is located at 34.01_ N latitude, 71.35_ E longitude, at an altitude of 350 m above sea level in Peshawar valley. The site is situated about 1600 km North of the Indian Ocean and has a continental type of climate. Warsak canal from Kabal River was used for the irrigation system. The soil of this site is clay loam, containing low in organic matter (0.87%), potassium (121 mg kg^{-1}); phosphorus (6.57 mg kg^{-1}), alkaline (pH 8.2); and with calcareous nature (Khan et al. 2009, So et al. 2012). The minimum, maximum temperature and average rainfall data was collected from the metrological station and shown in Fig 1 a & b.

2.2 Experimental design and agronomic practices

Experimental material consisted of 40 genotypes (39 Advance lines and 1 local check). These genotypes were planted under normal and late planting dates to study the effects of planting time on different genotypes. Experimental material was received from the National Agriculture Research Center (NARC) Islamabad as National Uniform Yield Trial (NUYT) 2013-14. The experiment was laid out in 5 × 8 alpha lattice design with 3 replicates. Every genotype was planted in a 6-row plot, having row to row and plant to plant distance of 0.25 m and 5 m, respectively. Normal planting was done on November 20, 2013, while late planting was done on December 21, 2013. All other cultural practices were applied uniformly to the experiments sown under normal and late planting dates. Three to four irrigations were applied during the wheat growth period.

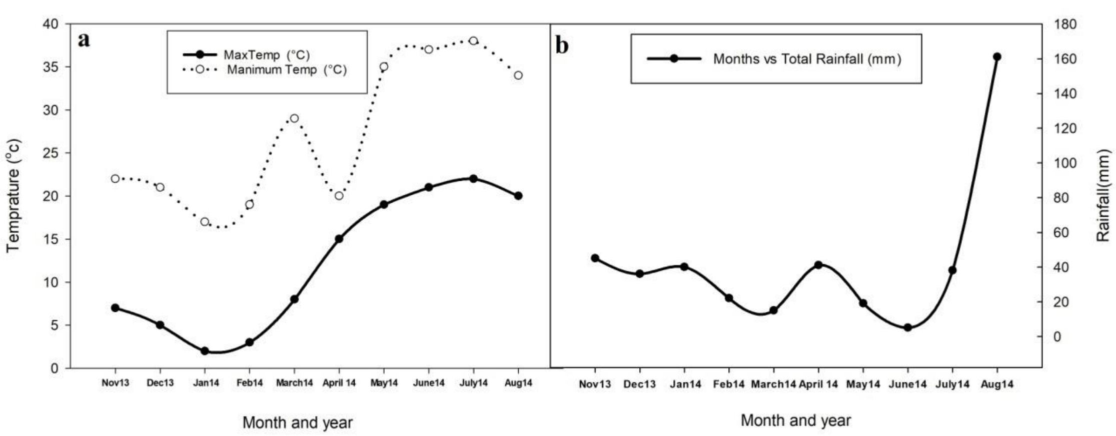

Figure 1. Mean monthly precipitation and air temperature during Nov 2013 to August 2014.

Table. 1. List of genotypes used in the experiment

Genotype	Code	Breeding center
1	109384	RARI- Bahawalpur
2	99172	RARI – Bahawalpur
3	99346	RARI – Bahawalpur
4	99114	RARI – Bahawalpur
5	DN-93	ARI- DI Khan
6	CT 09137	NIFA-Peshawar
7	SRN 09111	NIFA – Peshawar
8	V-09082	WRI – Faisalabad
9	V-09087	WRI – Faisalabad
10	V-10104	WRI – Faisalabad
11	V-10110	WRI – Faisalabad
12	V-11160	WRI – Faisalabad
13	SKD-11	WRI-Sakrand
14	NN-Gandum-I	NIBGE Fsd
15	NN-Gandum-II	NIBGE Fsd
16	TW96010	AZRI Bhakkar
17	TW96018	AZRI Bhakkar
18	SD-998	NIA Tandojam
19	NIA-MN-08	NIA Tandojam
20	CIM-04-10	NIA Tandojam
21	ESW-9525	NIA Tandojam
22	PR-103	CCRI-Pirsabak
23	PR-106	CCRI-Pirsabak
24	PR-107	CCRI-Pirsabak
25	RCA-1	RCA Seeds
26	V-11005	WRS-Tandojam
27	NR-413	NARC-Islamabad
28	NR-421	NARC-Islamabad
29	NR-409	NARC- Wheat
30	NR-419	NARC-Islamabad
31	UAF-9452	Univ. of Agri. Fiasalabad
32	Guard-C	Hybrid – Guard
33	SAWSN-02-102	AZRC-DI Khan
34	Janbazz	UOA Peshawar
35	TD-1	WRI-Sakrand
36	Pirsabak-13	CCRI-Pirsabak
37	Sehar-06	WRI-Faisalabad
38	V07096	WRI-Faisalabad
39	Aas-11	RARI- Bahawalpur
40	NARC-11	Wheat-NARC

2.3 Data collection and measurements

Days to emergence of wheat were observed in all plots by counting the number of days from sowing until the date when more than 70% of plants emerged. Days to heading were recorded by counting days in number from sowing until the date when more than 75% of tiller formed anthers. Data on plant height was recorded by taking the height of 5 tillers at random in each plot and the height from the base to the tip of each tiller was measured using a meter rod including awns and was then averaged. Flag leaf area was recorded at the panicle initiation stage. Days to physiological maturity of wheat were observed in all plots by counting the number of days from sowing until the date when more than 75% of tillers had become mature in all plots. Spikes m^{-2} was recorded by counting spikes in three middle rows and were then converted to m^{-2} using the same formula as spikes m^{-2}. Spike length was recorded at physiological maturity by using simple geometric ruler. Data on leaf chlorophyll content was recorded as a SPAD value using the Spad meter by putting the flag leaf on the scanner of the meter and hold for a while (Islam et al. 2014). Grains $spike^{-1}$ was noted by counting number of grains per spike in five randomly selected spikes in each plot and was averaged. Data on thousand grain weight was obtained by counting 1000 grains at random from the grain lot of each plot and were measured using an electronic balance. Biological yield was noted by harvesting three rows in the middle of each plot and were dried in an open field for one week and were then weighed and converted to kg ha^{-1} using equation 1. The grain yield was determined by threshing the harvested sample and the grain obtained was weighed and converted to kg ha^{-1}. Harvest index expressed in percentage is the ratio of seed yield to biological yield. It was determined by dividing seed yield by biological yield multiplied by 100.

BY(kg ha^{-1})= BY(kg) in four central rows× 10000/rows-row distance × number of number of rows × row length-------------(1)

2.3 Statistical Analysis

Analyses were carried and the significant means for various traits were separated with the application of LSD test. Sigma plot X7 was used for figure and data analysis was done through IBM-SPSS20 and Microsoft excel.

3. RESULTS

3.1 Phenology

Data on days to emergence, days to heading and days to maturity was considerably altered by wheat genotypes, normal and late planting. Days to emergence for wheat genotypes was recorded from 9 to 12 days under normal planting sowing and 25 to 29 days under late planting sowing condition (Table 2). Whereas among genotypes 109384, DN-93, V-10104, V-10110, V-11160 and NN-Gandum-I took minimum (9) days to emergence while genotype SD-998 took maximum (12) days to emergence. In contrast, genotypes DN-93 and UAF-9452 took minimum (25) days to emergence while genotype ESW-9525 took maximum (29) days to emergence under late planting condition. Average over normal and late planting days to emergence ranged from

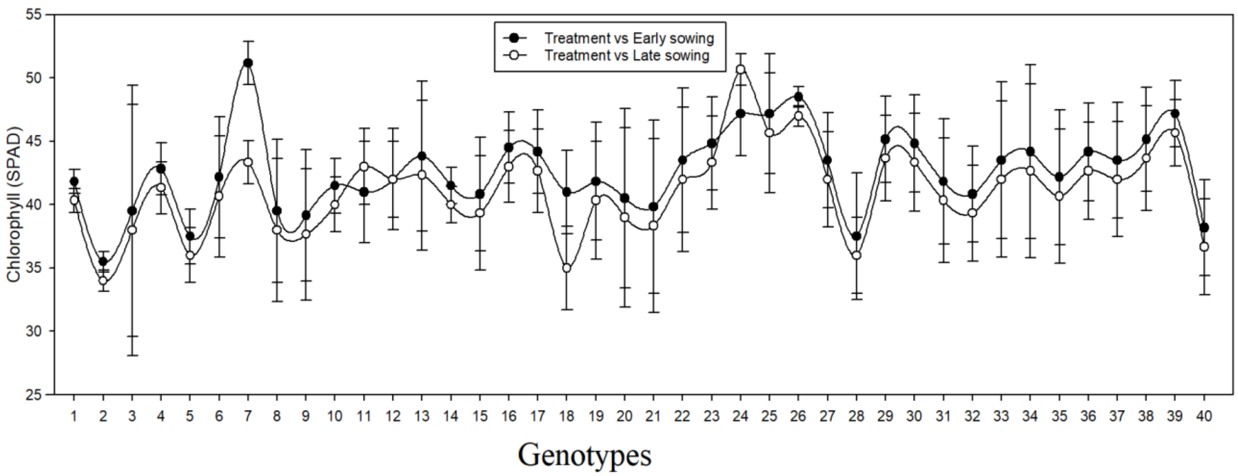

Figure 2. Chlorophyll content as influenced in different wheat genotypes and by sowing dates. Note: the serial numbers from 1 to 40 indicates the genotypes, for detail see table 1.

18 days for genotype NR-419 to 26 days for genotype PR-107. Mean values for 40 wheat genotypes for days to emergence were 10 and 26 days under normal and late planting sowing conditions, respectively (Fig. 3A).

Data on days to heading showed minimum (111) days to heading were observed for genotype PR-419 and maximum (121) days to heading were observed for genotypes CT 09137, SD-998 and NIA-MN08 under normal planting while at late planting minimum (95) days for genotypes TW96018 and PR-419 and maximum (107) days to heading were observed for genotypes DN-93 and ESW-9525 (Table 2). Genotype PR-419 took minimum days to heading under both normal and late planting conditions. The significant G×E interaction implies that the genotypes were observed to have different relative days to heading across planting dates. Mean genotypic performance across normal and late plantings for days to heading were 118 days in normal planting while 103 days in late planting(Fig. 3B). Thus in late sowing conditions the head in emergence 15 days were reduced as compared to normal sowing.

Data on day's physiological maturity under normal planting ranged from 155 to 164 days, while under late planting condition it ranged from 137 to 143 days (Table 2). Genotype UAF-9452 took minimum (155) days to physiological maturity while maximum (164) days to maturity were recorded for genotype NR-413 under normal planting. Under late planting condition minimum (137) days to maturity were recorded for genotype UAF-9452 while maximum (143) days to maturity were recorded for genotype NR-413. Interestingly the genotype UAF-9452 took minimum days while genotype NR-413 took maximum days to maturity under both normal and late planting. Mean days to maturity across two production environments ranged from 147 for genotype 99346 to 153 for genotype V-

09082. Average days to maturity were 159 and 140 days under normal and late planting conditions, respectively (Fig. 3C). From the net difference in days to maturity it was notice that the wheat genotypes planted at late planting condition get mature 19 days earlier than wheat genotypes sown at their normal sowing condition.

3.2 Growth traits

Data on wheat plant height were recorded significantly among genotypes and planting dates (Table 2). Generally, shorter plants were observed in late sowing as compared to the normal sowing date. Under normal planting conditions minimum (77 cm) plant height was observed for genotype TD-1 while genotype SAWN-02-102 showed maximum (125 cm) plant height. While genotype TD-1 showed minimum (63 cm) plant height and genotype SAWN-02-102 maximum (91 cm) plant height under late planting. Plant height in overall interaction value ranged from 63 cm for genotype TD-1 to 125 cm for genotype SAWN-02-102. Mean values across normal and late plantings were observed for genotype TD-1 to be 70 cm and 108 cm for genotype SAWN-04-102. Under normal planting the mean value was 105 cm while under late planting mean plant height of 80 cm was observed (Fig. 3D).

Spike length under normal planting varies from 10 to 13 cm and 8 to 12 cm under late planting condition (Table 2). Under normal planting genotype Guard-C showed minimum (10 cm) spike length while genotype 109384 showed maximum (13 cm) spike length. In contrast, genotype CT 09137 showed minimum (8 cm) spike length under late planting condition while genotype Aas-11 showed maximum (12 cm) spike length. Therefore, in normal sowing the genotype produced plants with maximum spike length. Mean value for spike length in overall interaction was ranged from 8 cm for genotype CT 09137 to 13 cm for genotype 109384. Mean over the two planting environments genotype Aas-11 produced plants with maximum spike length 13 cm while genotype CT 09137 produced plants with minimum spike length 9 cm. Mean for 40 wheat genotypes under normal and late planting were 12 and 10 cm respectively (Fig. 3E).

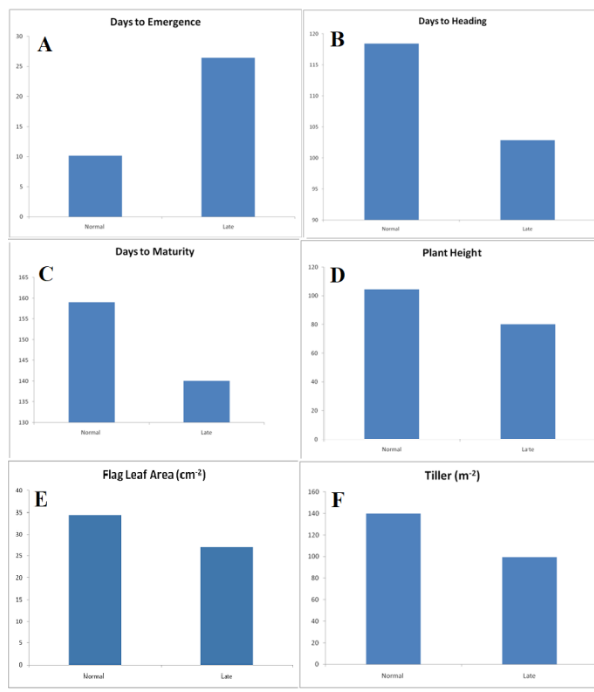

Figure 3. Impact of normal and late planting on yield and yield components of 40 breads wheat genotype.

Maximum (199) number of spikes m^{-2} were recorded for normal planting while minimum (57) spikes m^{-2} for late planting (Fig. 3F). Genotype Guard-C showed maximum (199) spikes m^{-2} while genotype

SAWSN-02-102 showed minimum (99) spikes m^{-2} under normal planting condition. Under late planting condition genotype CIM-04-10 showed minimum (57) number of spikes m^{-2} whereas genotype PR-107 showed maximum (145) number of spikes m^{-2}. The interaction mean value for number of spikes m^{-2} for normal and late planting ranged from 166 for genotypes Guard-C to 81 for genotype CIM-04-10 (Table 2). Mean values for 40 genotypes for spikes m^{-2} over normal and late planting were 140 and 100 respectively.

3.3 Physiological traits

The data recorded for flag leaf area under late planting ranged from 18 cm^2 to 37 cm^2, while under normal planting condition it ranged from 41 to 25 cm^2 (Table 2). Genotype DN-93 showed minimum flag leaf area of 18 cm^2, while genotype V-11005 exhibited maximum flag leaf area of 37 cm^2 under late planting while in normal planting condition minimum (25 cm^2) flag leaf area were observed for genotype NR-419, while maximum (41 cm^2) flag leaf area were recorded for genotypes PR-107 and RCA-1. The significant G × E interaction can be confirmed from the mean values for flag leaf area as the genotype showing maximum flag leaf area in normal sowing did not show maximum flag leaf area in late sowing which meant that the ranking of genotypes changed on the basis for their performance for flag leaf area under normal and late plantings. Based on the mean performance of genotypes under normal and late planting minimum flag leaf area was observed for genotype V-11160 (25 cm^2) while maximum for genotypes PR-107 and RCA-1 (38 cm^2). Averaged over 40 genotypes, flag leaf area was 27 and 34 cm^2 under normal and late planting conditions, respectively.

Data on chlorophyll content significant difference between genotypes and sowing dates. Between sowings dates early sowing showed higher chlorophyll content across the genotypes (Fig. 2). Among the genotypes no 7 in the Table 2 (SRN 09111) showed higher (51.1) chlorophyll content at early sowing (Figure 2), whereas during late sowing genotype number 24 resulted higher (50.6) chlorophyll content. The possible reason for this variation might be attributed to the genetic characteristics of the genotype as reported by (Kochak-Zadeh et al. 2013)

3.4 Yield components and yield traits

Data on number of grains $spike^{-1}$ were found significant for genotypes and planting date. Minimum number of grains $spike^{-1}$ (32) were observed in late sowing as average across 40 wheat genotype while normal sowing showed maximum (39) number of grains $spike^{-1}$ (Fig. 3F). Under late planting condition minimum (22) number of grains $spike^{-1}$ was observed for genotype CT 09137, while genotype Janbaz showed maximum (52) number of grains $spike^{-1}$. In contrast genotype CIM-04-10 produce maximum (59) number of grains $spike^{-1}$ while genotype Guard-C produce minimum (27) numbers of grain spike under normal planting (Table 2). Planting dates showed significant variation in number of grains $spike^{-1}$ in wheat genotypes. Number of grains $spike^{-1}$ in overall interaction value ranged from (22) for genotype CT 09137 to (59) for genotype CIM-04-10. Due to late

planting 18% reduction occurred in number of grains spike^{-1}. Sial et al. (2005) reported reduction in grain numbers due to late sowing and temperature Stress. The significant G × E interaction can be confirmed from the mean values for number of grains spike^{-1} as the genotype showing maximum number of grains spike^{-1} in normal sowing did not produce plants with maximum number of grains spike^{-1} in late sowing which means that the ranking of genotype in changed on the basis for their performance for number of grains spike^{-1} under normal and late planting.

Minimum (8533) biomass was recorded for genotype TD-1 and maximum (13667) biomass for genotype SRN 09111 at normal planting condition while at late planting minimum (2400 kg) and maximum (7933kg) biomass for genotype SD-998 and NR-421 respectively. Maximum and minimum biomass was observed for normal and late plantings which showed that the interaction effect of genotype and normal and late planting was effective in causing variation in genotypes for biomass. The genotypic effect was also observed significant which show that the genotypes are significantly different from each other for biomass. Averaged over normal and late planting minimum (5767 kg ha^{-1}) biomass was observed for genotype TD-1 while maximum (9700 kg ha^{-1}) for genotype NR-421. At late planting condition 55% reduction in bio-mass yield was observed. The 40 wheat genotypes produce an average 10885 kg ha^{-1} at normal plantings while the same genotypes sown late produce an average yield of 5990 kg ha^{-1} (Fig. 4K). It is obvious from the result that the wheat genotypes sown at their normal sowing period produce biomass yield of 4895 kg ha^{-1} than the wheat genotypes sown at late condition.

Data on 1000 grain weight demonstrates slighter (52 g) weight for genotypes SD-998 and NIA-MN-08, whereas heavier (88 g) 1000 grains weight was recorded for genotype SRN 09111 at normal planting while at late planting (36 g) and (75 g) for genotypes NIA-MN-08 and V 07096 respectively (Table 2). Interestingly the genotype NIA-MN-08 has resulted minimum 1000-grain weight under normal and late plantings. In overall interaction value for 1000 grain-weight ranged from (36 g) for genotype NIA-MN-08 to (88 g) for genotype SRN09111. The mean calculated for normal and late planting for 1000-grain weight genotype NIA-MN-08 had minimum (44 g) 1000-grain weight of and genotype V 07096 had maximum (75 g) of 1000 grain-weight. The average value calculated for 40 wheat genotype was 70 and 50g for normal and late planting respectively (Fig. 4G). Thus the kernel weight of wheat genotypes was reduced grain because of late sowing condition and hence normal planting was superior to late planting. The averaged 1000-grain weight of wheat genotypes was 20 g more than the wheat genotypes sown at late planting condition. 29 % weight loss was noticed at late planting condition.

Data on grain yield ranged averaged from 540 kg ha^{-1} for genotype NIA-MN-08 to 5336 for genotype SRN 09111 (Table 2). Data showed that under normal planting genotype NIA-MN-08 resulted Minimum (1869 kg ha^{-1}) grain yield and genotype SRN 09111 resulted in higher grain yield, while at late planting genotype NIA-MN-08

demonstrate lesser grain yield (540 kg ha^{-1}) and genotype PR-107 showed greater (2739 kg ha^{-1}) grain yield. Across normal and late plantings smallest amount of (1205 kg ha^{-1}) grain yield kg ha^{-1} was confirmed for genotype NIA-MN-08 and highest amount of (3329 kg ha^{-1}) grain yield for genotype V-11005. Normal planting produce more grain yield kg ha^{-1} than late planting (Fig. 4K).

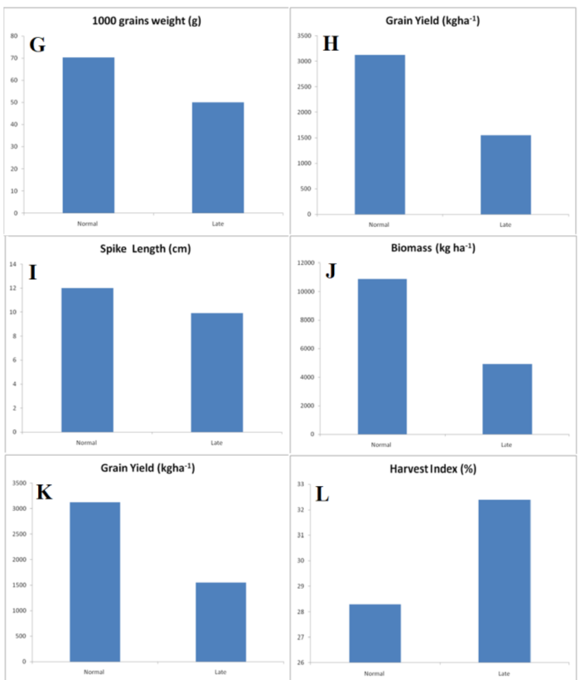

Figure 4. Impact of normal and late planting on yield and yield components of 40 breads wheat genotype.

Harvest index under normal planting ranged from 21 to 35 percent, while under late planting the harvest index ranged from 20 to 42 percent (Table 2). Genotype RCA-1 gave maximum harvest index of 35 percent whereas genotype SD-998 shows minimum harvest index of 21 percent under normal planting. Under late planting condition genotypes SD-998 and Guard-C gave maximum harvest index of 42 percent while genotype gave minimum harvest index of 20 percent (Fig. 4L).

4. Discussion

Planting time is one of the major causes of low yield in wheat. In normal course, the sowing of wheat must be completed in the month of November in Pakistan. But in some cases, wheat grown after Cotton, Rice, Sugarcane and fodder crops in rotation may be delayed up-to December. This reveals negative impact on the grain yield in wheat. Research activities regarding the role of planting time and identification of wheat genotypes having better performance in such situation is highly desirable. Whereas among genotypes 109384, DN-93, V-10104, V-10110, V-11160 and NN-Gandum-I took minimum (9) days to emergence while genotype SD-998 took maximum (12) days to emergence. In contrast, genotypes DN-93 and UAF-9452 took minimum (25) days to emergence while genotype ESW-9525 took maximum (29) days to emergence under late planting condition. Average over normal and late planting days to emergence ranged from 18 days for genotype NR-419 to 26 days for genotype PR-107. Mean values for 40 wheat genotype for days to emergence were 10 and 26 days under normal and late planting sowing conditions, respectively. Whereas genotype PR-419 showed less (111) days to heading(111) and more (121) days to heading were recorded for genotypes CT 09137, SD-998 and NIA-MN08 under normal planting, while at late planting minimum (95) days for genotypes TW96018 and PR-419 and maximum (107) days to heading were observed for genotypes DN-93 and ESW-9525 (Table 2).

Table 2: Mean performance of wheat genotypes for spikes m^{-2}, spike length, grain spike^{-1}, 1000 grain weight, bio-mass yield kg ha^{-1}, grain yield kg ha^{-1} and harvest index for wheat genotypes under Normal and late plantings 2013-14.

	Normal				Late			
Traits	Ranges	Means	Best Genotype	LSD (0.05)	Ranges	Means	Best Genotype	LSD (0.05)
Days to emergence (no)	9-12	10	109384	0.8	25-29	26	UAF-9452	1
Days to heading (no)	95-121	118	NR-409	0.8	95-107	103	NR-409	1.4
Plant Height (cm)	76.93-125.2	104.41	V-09082	1.2	63.26-90.66	80.38	Janbaz	3.4
Flag leaf Area (cm^2)	25.26-40.86	34.40	PR-107	1.6	17.69-36.73	27.28	V-11005	2.1
Days maturity (no)	155-164	159	UAF-9452	4.6	137-143	140	UAF-9452	1
Spike m^{-2} (no)	99-199	140	Guard-C	7	56-145	100	CIM-04-10	7
Spike length (cm)	9.7-13.2	11.63	109384	0.7	8.31-11.56	9.92	Aas-11	0.6
Grains spike^{-1}	27-59	39	CM-04-10	2	22-53	32	Janbaz	2
1000- grain weight (g)	51.74-87.59	70	SRN 09111	1.9	36.27-75.46	50.24	V07096	2
Bio-mass yield (kg ha^{-1})	8533-13667	11089	SRN 09111	403	2400-7933.3	4895	NR-421	390
Grain yield (kg ha^{-1})	1869-5336	3127	SRN 09111	51	540-27389	1548.21	PR-107	68
Harvest index	21-35	28	RCA-1	1.4	20.4-41.6	32.4	V-9082	2.7

While at late planting minimum (95) days for genotypes TW96018 and PR-419 and maximum (107) days to heading were observed for genotypes DN-93 and ESW-9525 (Table 2). Genotype PR-419 took minimum days to heading under both normal and late planting conditions. Data on days to physiological maturity under normal planting ranged from 155 to 164 days, while under late planting condition it ranged from 137 to 143 days. Genotype UAF-9452 took minimum (155) days to physiological

maturity while maximum (164) days to maturity were recorded for genotype NR-413 under normal planting. Under late planting condition minimum (137) days to maturity were recorded for genotype UAF-9452 while maximum (143) days to maturity were recorded for genotype NR-413. Average days to maturity were 159 and 140 days under normal and late planting conditions, respectively. It was observed that wheat genotypes sown at late planting condition emerged 16 days later than wheat genotypes sown at normal planting time to normal planting condition. The reason behind maximum days to emergence may be due to low temperature at late planting due to which wheat genotypes took maximum days to emerge as compared The same report was given by Benjamin (1990) and Gul et al (2012) as they observed that low temperature during emergence and seedling growth has detrimental effect on the crop establishment and productivity. Early emergence of head in wheat is one of the prime objectives in breeding programs of wheat because maximum time is available for grain filling. Late heading results in decrease grain size resulting in low grain weight (Irfaq et al, 2005). Among wheat genotype highly significant differences between genotype and environment interaction for days to heading are similar with the results of Razzaq et al. (1986), Subhan et al. (1991), Inamullah et al. (2007), Ilyas et al. (2013). Muhammad et al., (2007) conducted a research and observed significant result for days to heading across two environmental conditions. From the net difference in days to maturity it was notice that the wheat genotypes planted at late planting condition get mature 19 days earlier than wheat genotypes sown at their normal sowing condition. The wheat genotype took minimum days to get mature at late sowing because of continuity of race and to avoid from upcoming unfavorable condition. Nahar et al. (2010) reported up to 15% reduction in maturity period of wheat genotypes due to the effect of heat stress. Ilyas et al (2013) also found significant differences among wheat genotypes for days to maturity. Muhammad et al. (2007) also reported highly significant genotype by planting date interaction for days to maturity. The wheat genotype took minimum days to get mature at late sowing because of continuity of race and to avoid from upcoming unfavorable condition.

4.2 Growth traits

Plant height, Spike length and number of spikes m^{-2} were recorded significantly among genotypes and planting dates. Generally, shorter plants were observed in late sowing over normal sowing date. Genotype TD-1 results in shorter (77 cm) and genotype SAWN-02-102 showed taller (125 cm) plant height plant height under normal planting condition. Whereas under late planting genotype TD-1 showed minimum (63 cm) plant height and genotype SAWN-02-102 maximum (91 cm) plant height. Spike length under normal planting varies from 10 to 13 cm and 8 to 12 cm under late planting condition. Under normal planting genotype Guard-C showed minimum (10 cm) spike length while genotype 109384 showed maximum (13 cm) spike length. In contrast, genotype CT 09137 showed minimum (8 cm) spike length

under late planting condition while genotype Aas-11 showed maximum (12 cm) spike length. Number of spikes m^{-2} were recorded from 57 to 199 spikes m^{-2}. Among genotypes, genotype Guard-C showed maximum (199) spikes m^{-2} while genotype SAWSN-02-102 showed minimum (99) spikes m^{-2} under normal planting condition. The possible reason for increasing in plant height among cultivars might be due to the differences in their genetic makeup. These results are in agreement with those obtained by Wahid et al. (2017). Genotypic differences were also observed by Ahmad et al. (1997). Similarly, Laghari et al. (2012) found similar result that 32.54% reduction in plant height took place due to late sowing when compares to normal sowing. Reduction of 25 cm occurred as a result of late planting. Rashid et al. (2004) and Knapp and Knapp (1978) have also observed that wheat genotypes sown at late planting results in reduction in plant height. Irfaq et al., (2005) also reported reduction in plant height of wheat genotypes due to late sowing and high temperature stress.

Difference in spike lengths of the genotypes was also reported by Kakar et.al. (2003). Gul et al (2012) also found that sowing of wheat genotype at normal time produce maximum number spikes m^{-2} than late sowing. These significant differences are pointing towards the presence of sufficient genetic variations among the genotype. The results are in accordance with the findings of Munir et al (1999) and Rajora (1999).

Flag leaf area under late planting ranged from 18 cm^2 to 37 cm^2, while under normal planting condition it ranged from 41 to 25 cm^2. Averaged over 40 genotypes, flag leaf area was 27 and 34 cm^2 under normal and late planting conditions, respectively .Genotype DN-93 showed minimum flag leaf area of 18 cm^2, while genotype V-11005 exhibited maximum flag leaf area of 37 cm^2 under late planting while in normal planting condition minimum (25 cm^2) flag leaf area were observed for genotype NR-419, while maximum (41 cm^2) flag leaf area were recorded for genotypes PR-107 and RCA-1. Similarly for chlorophyll content, among the genotypes SRN 09111 showed higher (51.1) chlorophyll content at early sowing (Figure 2), whereas during late sowing genotype PR-107 resulted higher (50.6) chlorophyll content. The possible reason for this variation might be attributed to the genetic characteristics of the genotype as reported by Kochak-Zadeh et al. (2013). Rane et al. (2007) reported that cooler climates favored the vegetative as well as the reproductive phases of wheat growth.

4.4 Yield components and yield traits

In wheat, grains per spike, biomass, 1000 grain weight and grain yield is one of the important primary yield contributing character. Number of grains $spike^{-1}$, biomass, 1000 grain weight and grain yield were found significant for genotypes and planting date. Under late planting condition minimum (22) number of grains $spike^{-1}$ was observed for genotype CT 09137, while genotype Janbaz showed maximum (52) number of grains $spike^{-1}$. Similarly less biomass was recorded for genotype TD-1 and higher biomass for genotype SRN 09111 at normal planting condition while at late planting minimum and maximum

biomass were recorded for genotype SD-998 and NR-421 respectively. The 40 wheat genotypes produce an average 10885 kg ha^{-1} at normal plantings while the same genotypes sown late produce an average yield of 5990 kg ha^{-1}. Data on 1000 grain weight demonstrates slighter weight for genotypes SD-998 and NIA-MN-08, whereas heavier 1000 grains weight was recorded for genotype SRN 09111 at normal planting while at late planting lower and higher 1000 grains weight for genotypes NIA-MN-08 and V 07096 respectively. Grain yield showed that under normal planting genotype NIA-MN-08 resulted minimum grain yield and genotype SRN 09111 resulted in higher grain yield, while at late planting genotype NIA-MN-08 demonstrate lesser grain yield and genotype PR-107 showed greater grain yield. Across normal and late plantings smallest amount of grain yield kg ha^{-1} was confirmed for genotype NIA-MN-08 and highest amount of grain yield for genotype V-11005. The possible reason in the differences of bio-mass and yield attributes of the genotypes might be attributed to the genetic characteristic of each genotype as reported by Kakar et al. (2003). Akram et al. (2008) also found significant variation in wheat genotypes for 1000-grain weight. Abdullah et al. (2007) and Ansari et al. (1989) also found that late planting of wheat genotypes results in decrease of 1000- grain weight. Laghari et al (2012) and Irfaq et al (2005) reported biomass yield reduction in wheat genotypes because of late sowing. The finding of our research that the ranking of wheat genotypes according to yield production are changed by sowing the same wheat genotypes at two different environment are similar with the research findings of Cotes et al. (2006), Amin et al. (2005), Khalil et al. (2005), Garcya et al. (2003) and Kakar et al. (2003). Rane et al. (2007) reported that colder climates favored the vegetative as well as the reproductive phases of wheat growth

5. CONCLUSION

From this study it is concluded that late sowing of wheat negatively affect both morphological traits and grain yield and may results in 50 % of wheat yield loss. Hence timely sowing of wheat genotypes is highly suggested. The conducted research identified genotype SRN 19111 superior for 1000-grain weight, bio-mass yield and grain yield under normal planting, while genotype PR-107 exhibited higher grain yield under late planting. Therefore, these genotypes are recommended for further extensive testing and utilization in different wheat breeding programs.

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Competing interests

The authors declare no competing interests.

REFERENCES

Abdullah, M., Aziz-Ur-Rehman, N. Ahmad and I. Rasul. Planting time effect on grainand quality characteristics of wheat. Pak. J. Agri. Sci. (2007). Vol. 44 (2): 200-202.

Adnan, M., F. Muhammad, Q. Hussain, I. Hussain and F. Ali. Heritability estimates and correlation analysis in bread wheat (Triticum aestivum L.) under normal and late plantings. Pure Appl. Biol. (2017). 6 (4): 1151-1160.

Ahmed, N., M.A. Chowdhry, I. Khaliq and M. Maekaw. The inheritance of yield and yield components of five wheat hybrid populations under drought condition. Indo. J. Agric. Sci. (1997). 8(2): 53-59.

Kashtwari, M., Mansoor, S., Wani, A.A., Najar, M.A., Deshmukh, R.K., Baloch, F.S., Abidi, I. and Zargar, S.M. Random mutagenesis in vegetatively propagated crops: opportunities, challenges and genome editing prospects. Molecular Biology Reports. (2021). pp.1-21.

Ali, I., Khan, A.A., Munsif, F., He, L., Khan, A., Ullah, S., Saeed, W., Iqbal, A., Adnan, M. and Ligeng, J. Optimizing rates and application time of potassium fertilizer for improving growth, grain nutrients content and yield of wheat crop. Open Agriculture. (2019). 4(1), pp.500-508.

Ali, F., Yilmaz, A., Chaudhary, H.J., Nadeem, M.A., Rabbani, M.A., Arslan, Y., Nawaz, M.A., Habyarimana, E. and Baloch, F.S. Investigation of morphoagronomic performance and selection indices in the international safflower panel for breeding perspectives. Turkish Journal of Agriculture and Forestry. (2020). 44(2), pp.103-120.

Amin, M., Mohammad, T., Khan, A.J., Irfaq, M., Ali, A. and Tahir, G.R. Yield stability of spring wheat (Triticum aestivum L.) in the North West Frontier Province, Pakistan. Songklanakarin J. Sci. Technol. (2005). 27(6), pp.1147-1150.

Ansari, B.A., M.M. Rajper, A.J., Malik and A.G., Magsi. (1991). Heritability estimates of plant height, yield and yield components in Triticum aestivum L. Pak. J. Agric. Engg. Vet. Sci. 7: 35-40.

Azam, S.M., Mohammad, F., Ahmad, I., Khalil, I.H., Jadoon, S.A. and Nasim, A. Divergence in F3 segregating bread wheat populations. International Journal of Basic and Applied Sciences. (2013). 13(3), pp.94-99.

Cotes, J.M., Crossa, J., Sanches, A. and Cornelius, P.L. A Bayesian approach for assessing the stability of genotypes. Crop Science. (2006). 46(6), pp.2654-2665.

Dutta, S., Kumar, M. and Mukhopadhyay, K. Identification and Validation of Leaf Rust Responsive Wheat isomiRs and their Target Genes in both Wheat and Puccinia triticina. Tropical Plant Biology. (2019). 12(4), pp.318-335.

Ehdaie, B., Alloush, G.A., Madore, M.A. and Waines, J.G. Genotypic variation for stem reserves and mobilization in wheat: II. Postanthesis changes in internode water-soluble carbohydrates. Crop science. (2006). 46(5), pp.2093-2103.

Del Moral, L.G., Rharrabti, Y., Villegas, D. and Royo, C. Evaluation of grain yield and its components in durum wheat under Mediterranean conditions: an ontogenic approach. Agronomy Journal. (2003). 95(2), pp.266-274.

Gul, H., Saeed, B., Khan, A.Z., Haleema, B., Parveen, L. and Badshah, N.L. Morphological and some yield attributes in cultivars of wheat in response of varying planting dates and nitrogen application. Emergence. (2006). 1000, p.2.

Hamam, K.A. and Khaled, A.G.A. Stability of wheat genotypes under different environments and their evaluation under sowing dates and nitrogen fertilizer levels. Australian Journal of Basic and Applied Sciences. (2009) 3(1), pp.206-217.

Ilyas, M., F. Mohammad, I.H. Khalil, M. Arif, W. Khan, Saifullah and S.M. Azam. Yield Potential of F4:7 Bread Wheat Lines under Normal and Late Plantings. International Journal of Basic & Applied Sci. (2013). 13(05). 32-37.

Inamullah, N.H., Shah, Z.H. and FU, K. An analysis of the planting dates effect on yield and yield attributes of spring wheat. Sarhad J. Agric. (2007). 23(2), pp.269-275.

Irfan, M., Muhammad, T., Amin, M. and Jabbar, A. Performance of yield and other agronomic characters of four wheat (Triticum aestivum L.) genotypes under natural heat stress. Int. J. Bot. (2005). 1(2), pp.124-127.

Kakar, K.M., Kakar, Z. and Shawani, M.I. Varietal dynamics of yield stability in wheat. OnLine Journal of Biological Sciences (Pakistan). (2003).

Kattenberg, A. Climate models: projections of future climate (No. CONF-960146-). American Meteorological Society, Boston, MA (United States). (1996).

Khan, A., Jan, M.T., Marwat, K.B. and Arif, M. Organic and inorganic nitrogen treatments effects on plant and yield attributes of maize in a different tillage systems. Pak. J. Bot. (2009). 41(1), pp.99-108.

Khan, A., Jan, M.T., Marwat, K.B. and Arif, M. Organic and inorganic nitrogen treatments effects on plant and yield attributes of maize in a different tillage systems. Pak. J. Bot. (2009). 41(1), pp.99-108.

Kochak-Zadeh, A., Mousavi, S. and Nejad, M. The effect of salinity stress on germination and seedling growth of native and breeded varieties of wheat. J. Novel Appl. Sci. (2013). 12, pp.703-709.

Laghari, K.A., Sial, M.A. and Arain, M.A. Effect of high temperature stress on grain yield and yield components of wheat (Triticum aestivum L.). Journal of Science, Technology and Development. (2012). 31, pp.83-90.

Laghari, K.A., Sial, M.A., Arain, M.A., Mirbahar, A.A., Pirzada, A.J., Dahot, M.U. and Mangrio, S.M. Heritability studies of yield and yield associated traits in bread wheat. Pak. J. Bot. (2010). 42(1), pp.111-115.

Khan, M.I., Amin, M. and Shah, S.T. Agronomic evaluation of different bread wheat (Triticum aestivum L.) genotypes for terminal heat stress. Pak. J. Bot. (2007). 39 (7... Pak. J. Bot, 39(7), pp.2415-2425.

Munir, I., Swati, M.S., Muhammad, F., Ahmad, R. and Imtiaz, M. Heterosis in different crosses of wheat (Triticum

aestivum L.). Sarhad Journal of Agriculture (Pakistan). (1999).

Qamar, M. Genetic variability among wheat cultivars and effect of planting date ongrain and straw yield under double cropping zone of northern areas ofPakistan. Sarhad Journal of Agriculture (Pakistan). (2004).

TAHIR, M., ANWAR, S.A.S., ALI, A. and ISMAIL, M. Assessment of heritability estimates for some yield traits in winter wheat (Triticum aestivum L.). Pak. J. Bot. (2011). 43(6), pp.2733-2736.

Rane, J., Pannu, R.K., Sohu, V.S., Saini, R.S., Mishra, B., Shoran, J., Crossa, J., Vargas, M. and Joshi, A.K. Performance of yield and stability of advanced wheat genotypes under heat stress environments of the Indo-Gangetic plains. Crop science. (2007). 47(4), pp.1561-1573.

Rashid, M.H., Samanta, S.C., Biswas, P., Mannan, M.A. and Zaman, A.K.M.M., Performance of thirty wheat genotypes under late sown conditions in southern region of Bangladesh. Asian Journal of Plant Sciences (Pakistan). (2004).

Razzaq, A., Zada, K. and Shah, P., 1986. Effect of sowing dates and varieties on yield and yield components of wheat in the Peshawar valley [Pakistan]. Sarhad Journal of Agriculture (Pakistan).

Reynolds, M. P. Application of physiology in wheat breeding. Cimmyt, 2001.

Riaz-ud-Din, M.S., Ahmad, N., Hussain, M. and Rehman, A.U. Effect of temperature on development and grain formation in spring wheat. Pak. J. Bot. (2010). 42(2), pp.899-906.

Rosenthal, D.M. and Ort, D.R. Examining cassava's potential to enhance food security under climate change. Tropical Plant Biology. (2012). 5(1), pp.30-38.

Shoran, J. Estimation of variability parameters and path coefficients for certain metric traits in winter wheat (Triticum aestivum L. em. Thell.). Indian J Genet. (1995). 55(4), pp.399-405.

Sial, M.A., Arain, M.A., Khanzada, S.H.A.M.A.D.A.D., Naqvi, M.H., Dahot, M.U. and Nizamani, N.A. Yield and quality parameters of wheat genotypes as affected by sowing dates and high temperature stress. Pakistan Journal of Botany(2005). 37(3), p.575.

So, M.Y., Sha, S., Antoniou, M., Wu, S.S. and Tan-Un, K.C. Mycotoxin Zearalenone induced apoptosis in BEAS-2B cells through generation of ROS and activation of JNK and p38 MAPKs signalling pathways. In 6th SETAC World Congress/SETAC Europe 22nd Annual Meeting. SETAC Europe. The Abstracts Book's web site is located at http://berlin.setac.eu/scientific_programme/download_the_abstracts_book/?contentid=582.(2012).

Subhan, F., Haider, A. and Hatam, M. Effect of sowing dates on yield components of wheat cultivars. Sarhad Journal of Agriculture (Pakistan). (1991).

Vigna, B.B.Z., Jungmann, L., Francisco, P.M., Zucchi, M.I., do Valle, C.B. and de Souza, A.P. Genetic diversity and population structure of the Brachiaria

brizantha germplasm. Tropical Plant Biology. (2011). 4(3), pp.157-169.

Wahid, S.A. and Al-Hilfy, I.H. Impact of sowing dates on the growth and straw yield of some bread wheat cultivars and their relationship with accumulated heat units. Arts, humanities and natural sciences conferences. (2017). (Arabic Language)

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